LDRD proposal for large-area high-rate Time-of-Flight and Muon Telescope Detector with MRPC technology for EIC

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The development of Multi-Gap Resistive Plate Chamber (MRPC) provided new technology for time-of-flight detector. The STAR MRPC TOF detector upgrade, to be completed in 2009, is one of the first applications of such a technology in a large high energy particle and nuclear physics experiment with large coverage. The STAR MRPC detector typically has a rate capability of a few hundred particles per square cm. The detection efficiency would deteriorate significantly at higher particle flux. The limitation of the rate is largely due to the high resistivity of the glasses used in the construction of the MRPC module. The bulk resistivity of the glasses is on the order of 10^{12}-10^{13} Ω cm.

At EIC and also in other high beam luminosity applications, it is very desirable that the MRPC technology is also to be used for time-of-flight measurement because MRPC has a robust structure and has a good timing resolution. However, the rate capability of the existing MRPC technology is a severe restriction. We need to develop MRPC detectors with a rate capability up to a few KHz per square cm. This can be achieved by developing new glass or ceramic materials with lower bulk resistivity. With financial support from Chinese Funding Agencies the STAR Tsinghua University and USTC groups have developed silicate glasses and semi-conductor ceramics with bulk resistivity ranging from 10^{9}-10^{10} Ω cm. Prototype MRPC detector modules have been constructed with these materials.

We had also proposed an R&D research on a large-area and cost-effective muon telescope detector (MTD) for RHIC and for next generation detectors at future QCD Lab from state-of-art multi-gap resistive plate chamber (MRPC) with large module and long strips. Conventional muon detectors rely heavily on tracking stations while this R&D project proposes to use good timing and coarse spatial resolutions to identify muons with momentum of a few GeV/c. We have carried out timing resolution study at FermiLab test beam facility (T963), prototype in real environment at STAR in Au+Au collisions, and installed the prototype for p+p and d+Au collisions at RHIC in run 2007-2008. This allows us to assess the detector time resolution, and its trigger and particle identification capability. The focus of the new R&D will be on simulations on muon identification requirements based on physics cases and assessments on online trigger conditions with the MTD under EIC conditions.

We propose the following:

1) Produce prototype with new materials for high-rate environment and test the prototype with beam conditions to study long term stability and performance;
2) Carry out simulations with EIC physics and beam conditions to further improve our design and detector requirements on Time-of-Flight related components. This includes a large-area barrel Time-of-Flight, the start timing detector with tagged out-going beam electron, Muon telescope detector for muon identification with MRPC at EIC environment;
3) The intrinsic resolution of the MRPC detector is about 30—40ps while the current resolution at STAR, PHENIX and ALICE achieved is in the order of 60—100ps. R&D on possible improvements of electronics and for high-rate readout as well.